THE SIGNAL AVERAGED ELECTROCARDIOGRAM IN PREDICTING CORONARY ARTERY DISEASE

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The ability to detect coronary artery disease (CAD) by signal averaged electrocardiogram was tested in patients with no known organic heart disease undergoing diagnostic cardiac catheterization. A pilot study revealed that a QRS duration ≥ 100 msec, a root mean square (RMS) voltage in the terminal 40 msec of the QRS <50uV, and a low amplitude signal (LAS) duration >28 msec was suggestive of CAD. These parameters were then used prospectively to examine 40 consecutive patients, referred for cardiac catheterization. Patients with CAD had significantly longer QRS durations (103±10 vs 91±8 msec;p<0.05), lower RMS voltages (36±22 vs 66±32 uV; p<0.05), and longer LAS durations (33± 8 vs 23±7 msec; p<0.05), as compared to patients without CAD. The sensitivity, specificity, and positive predictive value (PPV) of these parameters were as follows:

	SENSITIVITY	SPECIFICITY	PPV
QRS>100 msec	62%	89%	87%
RMS<50 uV	76%	74%	75%
LAS>28 msec	71%	74%	75%
All 3 Parameters	52%	95%	92%

Late potentials occurred rarely in our study (5 patients), but only in the CAD group. This approach offers promise as a noninvasive tool in assessing patients for CAD.

VALUE OF SIGNAL AVERAGED ELECTROCARDIOGRAM IN PREDICTING STRUCTURAL HEART DISEASE IN PATIENTS WITH SUSTAINED VENTRICULAR TACHYCARDIA.

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Signal averaged electrocardiograms (SAECGs) often reveal late potentials in patients with sustained ventricular tachycardia (VT-S) and structural heart disease (SHD). SAECG findings in patients with VT-S without SHD (NOSHD) are unknown. The SAECGs(40 Hz filter noise <0.5uvolts) of 35 patients with VT-S (15 NOSHD, 20 SHD) were therefore compared. Abnormal (Abn) findings were QRS duration (QDur) >114msec, terminal 40 msec voltage (RMS40) ≤20uvolts and signal <40uvolts >38 msec (LAS). Results:

	NOSHD	SHD(#abn)	p value
#	15	20	
age	34±10	59±3	<0.01
QDur	99±8(0)	130±30(13)	<0.01(<0.01)
RMS40	44±28(3)	23±22(15)	<0.05(<0.01)
LAS	29±8(3)	46±20(13)	<0.01(<0.01)
AbnSAECG(%)	3(20%)	16(80%)	<0.01

Normal SAECG was 80% sensitive and 80% specific in predicting NOSHD. Conclusions: 1) in patients with VT-S, SAECG distinguishes between those with and without SHD; 2) SAECG is rarely abn in patients with VT-S and structurally normal hearts; 3) VT-S in these patients may be due to abn automaticity or triggered activity.

Three-Dimensional Spectrotemporal Mapping of the Signal-Averaged ECG Identifies Patients With Ventricular Tachycardia Despite the Presence of Bundle Branch Block

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Prior studies using analysis of the signal-averaged ECG (SAECG) in the time or frequency domains showed difficulty in identifying the ventricular tachycardia (VT) pt when bundle branch block (BBB) was present. We performed 3D spectrotemporal mapping of the SAECG signal analyzing a moving window of 128 ms with the fast-Fourier transform in 10 normals, 16 pts with prior myocardial infarction (MI), 14 pts with prior MI and VT, 16 with prior MI and BBB, and 13 pts with prior MI, BBB, and VT. There were 10 pts with right BBB and 14 pts with left BBB.

Different methods of analysis were required to distinguish VT from non VT pts depending on whether BBB was present. There were no false positives in the 10 normal pts. Without BBB, increased frequency content at 50-75 Hz in the terminal QRS identified the VT pt with a sensitivity of 86%, specificity of 81%, and accuracy of 83% ($p < 0.005$ by chi square). With BBB, increased frequency content at 75-250 Hz in the terminal QRS identified the VT pt with a sensitivity of 92%, specificity of 83%, and accuracy of 76% ($p < 0.005$ by chi square).

Spectrotemporal mapping produced clear patterns that allowed visual discrimination between pt groups in most cases. In the presence of BBB, examination of a higher frequency band (75-250 Hz) was required to identify the VT pt. These data suggest cautious optimism for the clinical use of this noninvasive method to identify pts with BBB at increased risk for sustained VT.

QUANTITATIVE CHARACTERIZATION OF ATRIAL FIBRILLATION AND FLUTTER WAVES: A NOVEL APPROACH USING SPECTRAL SIGNAL AVERAGING.

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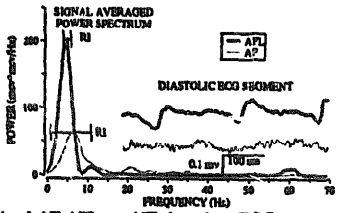
Between Atrial fibrillation (AF) and flutter (AFL) there exist a continuum of atrial electrical activity that is thought to influence responses to interventions such as DC cardioversion or atrial pacing. We developed a non-invasive technique to quantitatively characterize these atrial arrhythmias based on independent measures of atrial rate, regularity, and courseness. Orthogonal (XYZ) ECG's were recorded in 10 patients with AF or AFL onto a laboratory computer. Multiple (>20) diastolic ECG segments (each 512 ms duration) were selected, and Fast Fourier Transforms of each segment were calculated. The resulting power spectra were signal averaged within each lead. Waveform courseness and rate were measured from the peak signal averaged power and the frequency at peak power, respectively. A waveform regularity index (RI) was defined as the bandwidth about the peak frequency in which 50% of the total power was contained (figure). Tachycardia regularization is thus indicated by narrowing of RI. Though AF waveforms varied from beat-to-beat, their corresponding power spectra were morphologically stable over time. Even "fine" AF exhibited reproducible spectra and a peak frequency was easily identified (figure). In any given patient, frequency content was similar in each orthogonal lead, though waveform magnitude was greatest in the superior-inferior axis (Y lead). When waveforms were classified as AF, mixed AF-AFL, or AFL based on ECG appearance, peak frequencies were similar 4.0 ±1.2 Hz, 5.4 ±1.4 Hz, 4.8 ±1.7 Hz, however, these 3 subgroups were easily discriminated ($p<0.05$) by their RI: AF = 9.5 ±2.0 Hz, AF-AFL = 5.9 ±1.9 Hz, AFL = 2.0 ±0.4 Hz. Furthermore, RI did not correlate with simple waveform features such as courseness and thus can not be reliably assessed by ECG inspection alone.



CONCLUSIONS: Patients with AF or AFL manifest a broad range of atrial synchrony which can be quantified non-invasively by frequency domain analysis. Objective analysis of atrial waveform properties may prove helpful in predicting responses to therapeutic interventions.